

GATE | PSUs



CIVIL ENGINEERING

Geomatics Engineering

Text Book : Theory with worked out Examples
and Practice Questions



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01. Fundamental Concepts

01. Ans: (c)

Sol: Plan area = $9.5 \times 11.5 \text{ cm}$

$$= 109.25 \text{ cm}^2$$

$$\text{Ground area} = 63500 \text{ m}^2$$

$$\begin{aligned} \text{Scale} &= \sqrt{\frac{\text{Map area}}{\text{Ground area}}} \\ &= \sqrt{\frac{109.25 \times 10^4}{63500}} \approx \frac{1}{2411} \end{aligned}$$

02. Ans: (a)

Sol: Shrinkage factor = $[100 - 6\%]$

$$= 94\%$$

$$= 0.94$$

$$L = ? \quad B = ?$$

$$L = \frac{6}{0.94} \quad B = \frac{9}{0.9}$$

$$L = 6.38 \text{ cm} \quad B = 9.58 \text{ cm}$$

$$\text{Dimension} = 6.38 \times 9.58 \text{ cm}$$

03. Ans: (c)

Sol: Least count = $\frac{S}{n}$

$$0.01^\circ = \frac{\left(\frac{1}{5}\right)^\circ}{n}$$

$$\text{Vernier dividing } n = 20$$

$$\text{Number of main scale dividing} = 2n - 1$$

$$= 2 \times 20 - 1$$

$$= 39$$

04. Ans: (1 in 555.55)

Sol: Original R.F = 1 : 500

$$\text{Shrunk factor} = 0.9$$

$$\begin{aligned} \text{Revised R.F.} &= \frac{1}{500} \times 0.9 \\ &= 1 \text{ in } 555.55 \end{aligned}$$

05. Ans: (c)

Sol: Theodolite is divided into degrees and half degrees in the length of 59 MSD, LC of direct vernier ?

$$\text{L.C.} = \frac{S}{n}$$

$$S = \frac{1}{2} = 30'$$

In direct vernier, 'n' div of V = (n - 1) div of M.S. $n - 1 = 59$

$$n = 60$$

$$\therefore \text{L.C.} = \frac{30'}{60} = \frac{(30 \times 60)''}{60} = 30''$$

06. Ans: (c)

Sol: 1 cm = 100 m; O.L = 100 cm;

$$\text{S.L.} = 95 \text{ cm}; \quad \text{M.A} = 810 \text{ cm}^2,$$

Correct Area = ?

Actual area in km² of survey

Planimeter which is a minor instrument is used for measurement of area of a map.

$$C.A. = \frac{M.A.}{(S.F.)^2}$$

$$S.F. = \frac{95}{100} = 0.95$$

$$C.A. = \frac{810}{(0.95)^2} = 897.501$$

$$= 897.51 \text{ cm}^2 \text{ (on map)}$$

Scale:

$$1 \text{ cm} = 100 \text{ m}$$

$$C.A = 897.51 (100 \times 100)$$

$$= 8.9751 \times 10^6 \text{ m}^2$$

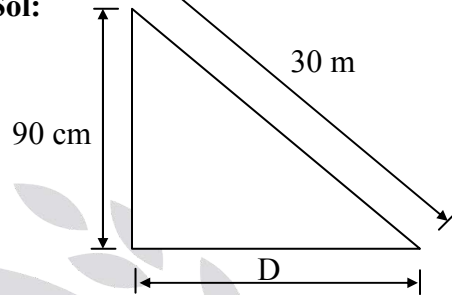
$$= 8.9751 \times 10^6 \times 10^{-6} \text{ km}^2$$

$$C.A. = 8.9751 \text{ km}^2 \text{ (on ground)}$$

02. Linear Measurement Including Chain Survey

01. Ans: (c)

Sol:

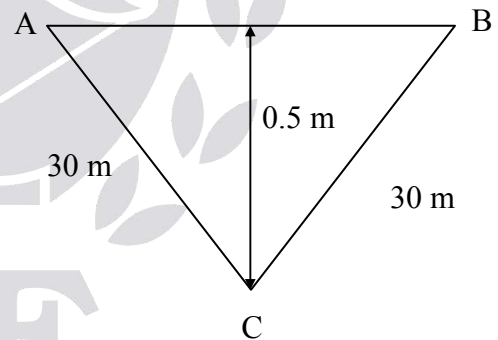


$$D = \sqrt{(30)^2 - 0.9^2}$$

$$= 29.986 \text{ cm}$$

02. Ans: 59.992 m

Sol:



$$C_{M.A} = \frac{d^2}{L}$$

$$= \frac{(0.5)^2}{30} = 0.008 \text{ m (-ve)}$$

$$\text{Correct distance} = 60 - 0.008$$

$$= 59.992 \text{ m}$$

03. Ans: (d)

$$\text{Sol: } C_{\text{sag}} = \frac{w^2 L}{24P^2}$$

$$= \frac{25^2 \times 50}{24 \times 150^2}$$

$$= 0.0579 \text{ m (-)}$$

$$\text{Correct distance} = 50 - 0.0579$$

$$= 49.942 \text{ m}$$

04. Ans: (b)

$$\text{Sol: } \tan 60^\circ = \frac{BD}{BC}$$

$$BD = 250 \tan 60^\circ$$

$$= 433.012 \text{ m}$$

$$\sin 60^\circ = \frac{BD}{CD}$$

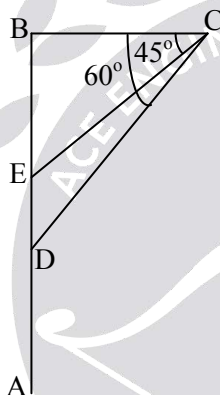
$$CD = 500 \text{ m}$$

$$\tan 45^\circ = \frac{EB}{BC}$$

$$EB = 250 \text{ m}$$

$$\sin 45^\circ = \frac{BE}{EC}$$

$$EC = 354 \text{ m}$$



05. Ans: 213 m

$$\text{Sol: } \sin \theta_1 = \frac{180}{300}$$

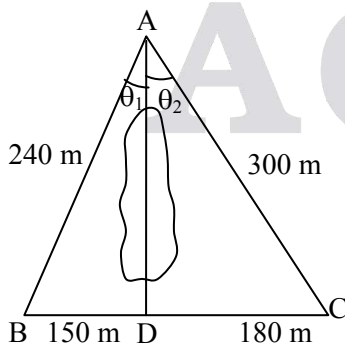
$$\theta_1 = 36.86$$

$$\sin \theta_2 = \frac{150}{240}$$

$$\theta_2 = 38.68$$

$$\theta = \theta_1 + \theta_2 = 75.54$$

$$150 + 180 = 330$$



$$\tan\left(\frac{\theta}{2}\right) = \frac{330/2}{AD}$$

$$AD = 212.9 \text{ m}$$

$$\approx 213 \text{ m}$$

06. Ans: (d)

Sol: Length of chain $L = 30\text{m}$

Incorrect length of chain $L' = 29.8\text{m}$

Measured distance $\ell' = 450 \text{ m}$

$$\text{Actual distance} = \ell' \left(\frac{L}{L'} \right)$$

$$= 450 \times \frac{29.8}{30} = 447 \text{ m}$$

07. Ans: (a)

Sol: Length of base line = 2500 m

Elevation = 200 m

Radius of the earth $R = 6370 \text{ km}$

$$C_{\text{MSL}} = \frac{Lh}{R}$$

$$= \frac{2500 \times 200}{6370 \times 10^3} = -0.0785 \text{ m}$$

The correction is negative, if the measured distance is above MSL.

08. Ans: (b)

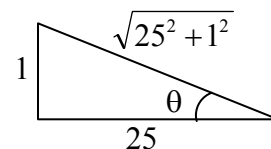
Sol: Slope correction = ?

Length = 60 m

Gradient = 1 in 25

$$\cos \theta = \frac{25}{\sqrt{25^2 + 1^2}} = 0.99$$

$$= 60 (1 - \cos 2.29) = 48 \text{ mm}$$



09. Ans: (d)

Sol: Length of tape $L = 30$ m

Pull = 10 kg

3 spans of 10 m

Area of cross section $A = 0.08$ sq. cm

Density of tape = 7.86 g/cc

$$\text{Correction for sag} = \frac{w^2 \ell}{24n^2 P^2}$$

$$w = 7.86 \times 0.08 \times 30 \times 100 = 1.88 \text{ kg}$$

$$C_{\text{sag}} = \frac{(1.88)^2 (30)}{24 \times 3^2 \times 10^2} = -0.0049 \text{ m}$$

10. Ans: (a)

Sol: 30 m chain 10 cm too long measured distance = 2500 m

15 cm too long at the end of day total distance = 4500 m

True distance = ?

$$\text{For 2500 m; } L' = \frac{30 + 30.1}{2} = 30.05 \text{ m}$$

$$\ell_1 = 2500 \times \frac{30.05}{30} = 2504.16 \text{ m}$$

$$\text{For 2000 m; } L' = \frac{30.1 + 30.15}{2} = 30.125$$

$$\ell_2 = 2000 \times \frac{30.125}{30} = 2008.33 \text{ m}$$

$$\begin{aligned} \text{Total} &= 2504.16 + 2008.33 \\ &= 4512.49 \text{ m} \end{aligned}$$

11. Ans: (d)

Sol: Length of tape = 50 m

Std. temperature = 20°C

Pull = 10 kg

Measured temperature = 50°

$$\alpha = 1 \times 10^{-6}/^\circ\text{C}$$

$$\begin{aligned} C_{\text{Temp}} &= l \alpha \Delta T \\ &= 50 \times 1 \times 10^{-6} (50 - 20) \\ &= 1.5 \times 10^{-3} \text{ m} \end{aligned}$$

True length of a tape = 50.0015 m

03. Compass Survey

01. Ans: (a)

Sol: M.B = N 5° 30' E (5° 30')

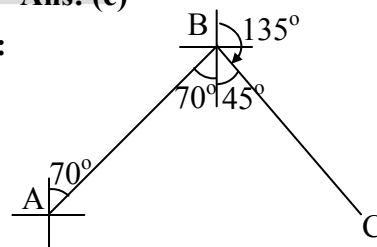
T.B = N 10° 30' W (349° 30')

Magnetic declination = T.B - M.B

$$\begin{aligned} &= 349^\circ 30' - 5^\circ 30' \\ &= 344^\circ \\ &= 16^\circ \because 360^\circ - 344^\circ \\ &= \text{N } 16^\circ \text{W} \end{aligned}$$

02. Ans: (c)

Sol:



$$\angle B = 70^\circ + 45^\circ = 115^\circ$$

03. Ans: (d)

$$\text{Sol: W.C.B} = \frac{6\pi}{3} \times \frac{180}{\pi} = 360^\circ$$

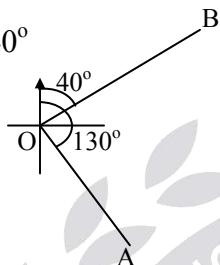
$$= 0^\circ\text{N}$$

04. Ans: (c)

Sol: Included angle

$$= 130^\circ - 40^\circ$$

$$= 90^\circ$$



05. Ans: (a)

Sol: Bearing of RS

$$= 180^\circ + 30^\circ$$

$$= 210^\circ$$



06. Ans: (b)

Sol:

Line	F.B
PQ	50°
QR	170°
RS	230°
SP	310°

F.B of SP – F.B of SR

$$\angle S = 310^\circ - (230^\circ - 180^\circ) = 260^\circ$$

07. Ans: (d)

Sol:

Line	FB	BB	Corrected		Correction
			FB	BB	
AB	126°30'	307°45'	127°15'	307°15'	-0°30' @ B
BC	49°	227°15'	48°30'	228°30'	+1°15' @ C
CD	340°15'	161°30'	341°30'	161°30'	
DE	258°15'	78°15'	258°15'	78°15'	
FA	212°15'	31°30'	212°15'	32°15'	+0°45' @ A

08. Ans: (a)

Sol: D = 6°30' W

MB = ?

$$\text{TB} = \text{S}32^\circ30'\text{E} = 147^\circ30'$$

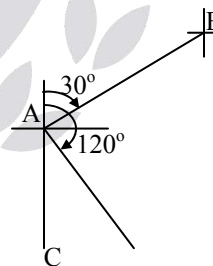
$$\text{TB} = \text{MB} \pm \text{D}$$

$$147^\circ30' + 6^\circ30' = \text{MB}$$

$$\text{MB} = 154^\circ$$

09. Ans: (a)

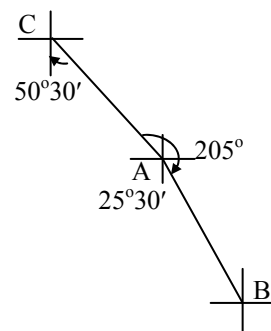
Sol:



$$\angle \text{BAC} = 90^\circ$$

10. Ans: (b)

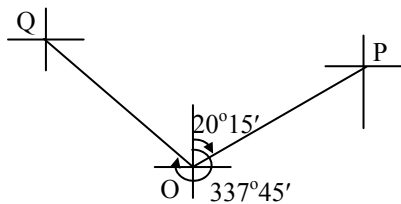
Sol:



$$\angle \text{CAB} = 205^\circ$$

11. Ans: (d)

Sol:



$$\angle QOP = 42^\circ 30'$$

12. Ans: (b)

Sol: True bearing = magnetic bearing $\pm$ declination

$$= 187^\circ 30' - 2^\circ = 185^\circ 30'$$

$$\text{T.B} = 185^\circ 30' - 3^\circ 30' = 182^\circ$$

13. Ans: (b)

Sol: FB of PA

$$= \text{N}48^\circ 45' \text{W} (360^\circ - 48^\circ 45' - 311^\circ 15')$$

$$\text{BB of PA} = 311^\circ 15' - 180^\circ = 131^\circ 15'$$

$$= \text{FB of AP}$$

Observed F.B of AP $\text{S}50^\circ 30' \text{E}$ ($129^\circ 30'$)

$\therefore$ Correction for L.A = $+1^\circ 45'$ at A

$$\text{Corr. M F.B of AB} = 80^\circ 50' + 1^\circ 45'$$

$$= 82^\circ 35'$$

$$\text{Corr T.B of AB} = 82^\circ 35' + 3^\circ = 85^\circ 35'$$

$$= \text{N}85^\circ 35' \text{E}$$

14. Ans: (d)

Sol:

Line	F.B	B.B	
AB	20°	201°	$200^\circ - 1^\circ$ at B
BC	100°	280°	
CA	230°	50°	

15. Ans: (a)

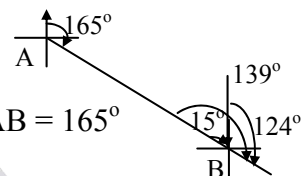
Sol:

Bearing of a line AB = 165°

$$\angle ABC = 139^\circ$$

$$\text{FB of BC} = 139^\circ - 15^\circ$$

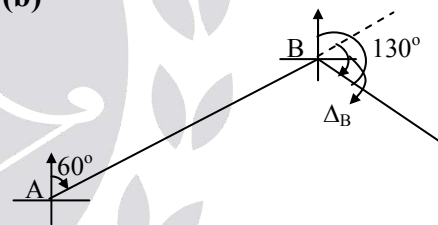
$$= 124^\circ$$



16. Ans: (b)

Sol:

$$\Delta_B = 130^\circ - 60^\circ = 70^\circ$$



BS	IS	FS	Rise	Fall	RL
0.750					100.50
	1.550			-0.80	
	2.250			-0.70	
	2.850			0.60	
1.75		3.550		-0.70	
	2.450			-0.70	
0.950		3.650		-1.20	
	2.95			-2.0	
	3.15			-0.2	
		3.75		-0.6	93.00

04. Plane Table Survey

01. Ans: (c)

Sol: $PP' = e.K$

$$E = 50 \text{ cm} = 500 \text{ mm};$$

$$K = \frac{1}{1000}$$

$$= 500 \cdot \frac{1}{1000} = \frac{1}{2} = 0.5 \text{ mm}$$

02. Ans: 0.125 mm

Sol: $PP' = e.K$

$$K = \frac{1}{2000}$$

$$= 250 \cdot \frac{1}{2000} = 0.125 \text{ mm}$$

03. Ans: (c)

04. Ans: (d)

05. Levelling

01. Ans: 1 in 24

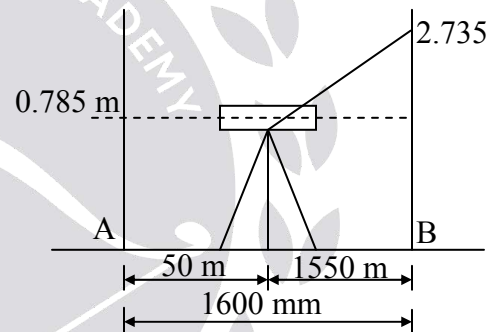
Sol: 0.750, 1.55, 2.25, 2.85, 3.55, 1.75, 2.45, 3.65, 0.950, 2.95, 3.15, 3.75

$$\text{Gradient} = \frac{\text{Difference in RL's}}{9 \times 20}$$

$$= \frac{7.50}{9 \times 20} = 1 \text{ in } 24$$

02. Ans: (a)

Sol:



$$\begin{aligned} \text{C.S.R on B} &= 2.735 - 0.06735 \times 1.55^2 \\ &= 2.573 \text{ m} \end{aligned}$$

$$\begin{aligned} \text{T.R.L difference between A \& B} &= 2.573 - 0.785 \\ &= 1.788 \text{ m} \approx 1.8 \text{ m} \end{aligned}$$

03. Ans: (b)

Sol: Dip of horizon, $\theta = \frac{D}{R}$ in radians

$$d = \sqrt{\frac{h}{0.06735}} = \sqrt{\frac{45}{0.06735}}$$

$$d = 25.84 \text{ m}$$

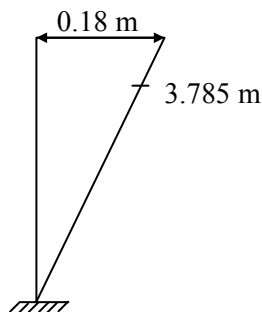
$$\theta = \frac{25.84}{6371} = 0.004 \text{ m}$$

04. Ans: 3.781 m

Sol: The correct reading

$$= \sqrt{3.785^2 - 0.18^2}$$

$$= 3.781 \text{ m}$$



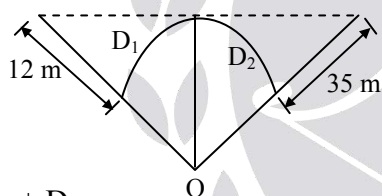
05. Ans: (a)

Sol: Radius of curvature of bubble tube $= \frac{nD}{S}$

$$= \frac{5 \times (2 \times 10^{-3}) \times 100}{0.05} = 20 \text{ m}$$

06. Ans: (b)

Sol:

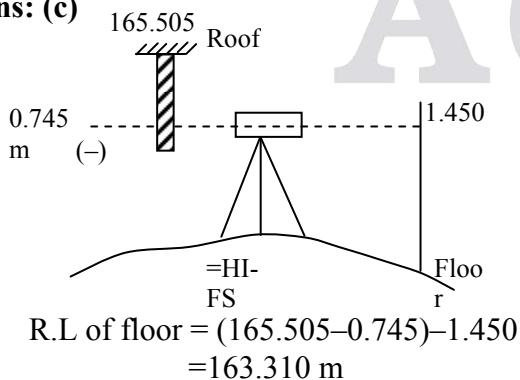


$$D = D_1 + D_2$$

$$= \sqrt{\frac{12}{0.06735}} + \sqrt{\frac{35}{0.06735}} = 36.144 \text{ km}$$

07. Ans: (c)

Sol:



08. Ans: (a)

Sol: Instrument

Staff reading

	A	B
A	1.625	2.545
B	0.725	1.405
$A_1 \rightarrow A \Rightarrow h_a$	$B_1 \rightarrow A \Rightarrow h_a'$	
$A_1 \rightarrow B \Rightarrow h_b$	$B_1 \rightarrow B \Rightarrow h_b'$	

I-Instrument Set up:

$$N \rightarrow N \Rightarrow h_a$$

$$\rightarrow F \Rightarrow h_b$$

II-Instrument Setup:

$$\text{Near to near} = h_b'$$

$$\text{Near to further} = h_a'$$

$$e = \frac{-1}{2} [(h_a - h_b) - (h_a' - h_b')]$$

$$= \frac{-1}{2} [(1.625 - 2.545) - (0.725 - 1.405)]$$

$$= 0.12$$

$$e = e_{col} + e_c + e_R$$

$$0.12 = e_{col} + 0.07857(1)^2 + (-0.01122(1)^2)$$

$$e_{col} = 0.05265 \text{ m}$$

$$\theta = \tan^{-1} \left(\frac{0.05265}{1000} \right) = 10.86''$$

09. Ans: 151.90 m

Sol: $\sum \text{Rise} - \sum \text{Fall} = \text{Last R.L.} - \text{First R.L.}$

$$2.645 - (1.245) = \text{L.R.L} - 150.500$$

$$\Rightarrow \text{L.R.L} = 151.90 \text{ m}$$

10. Ans: (d)

$$\text{Ans: } 60^2 = \frac{h}{0.06735} \Rightarrow h = 242.46 \text{ m}$$

11. Ans: (a)

Sol: 0.680 m, 1.455 m, 2.330 m, 2.885 m,
3.380 m 1.055 m

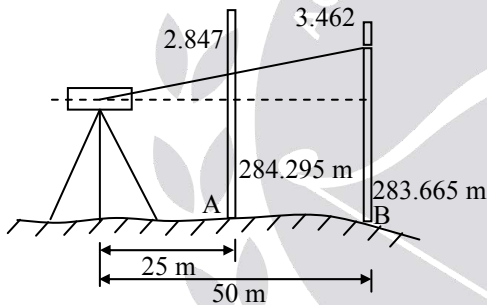
Stn.	BS	IS	FS	Rise	Fall	RL	Remarks
1	0.680					81.305	
2.		1.455			0.775		
3.		2.330			0.875		
4.		2.885			0.555	79.100	
5	1.055	3.380					

$$81.305 - 0.775 = \text{RL of 2}$$

$$\text{RL of 2} - 0.875 = \text{RL of 3}$$

12. Ans: (d)

Sol:



$$\text{Difference in staff reading} = 3.462 - 2.847$$

$$= 0.615 \text{ m}$$

$$\text{Difference in R.L.} = 284.295 - 283.665 \text{ m}$$

$$= 0.63 \text{ m}$$

$$\text{Difference of the above} = 0.615 - 0.63$$

$$= 0.015 \text{ m}$$

$$e_{\text{col}} = 0.015 \text{ m of 25 m}$$

$$100 \text{ m} \rightarrow \frac{100}{25} \times 0.015$$

$$= 0.06 \text{ m}$$

13. Ans: (a)

$$\text{Sol: } \Sigma B.S - \Sigma F.S = L.R.L - F.R.L$$

$$-6.2 - (? + 0.85) = 196.1 - 200$$

$$? = -3.150 \text{ m}$$

14. Ans: (a)

$$\text{Sol: } H = \frac{1}{2}[(1.03 - 1.630) + (0.950 - 2.740)]$$

$$= -1.195$$

$$\text{R.L of Q} = 450 - 1.195$$

$$= 448.805 \text{ m}$$

15. Ans: (b)

Sol:

BS	IS	FS
3.425		
	2.650	
2.150		0.850
2.850		1.780
	1.250	
		0.525

16. Ans: (d)

$$\text{Sol: } \begin{array}{cc} P & Q \\ P & 1.525 \quad 2.325 \\ Q & 1.545 \quad 2.265 \end{array}$$

$$e = \frac{-1}{2}[(1.525 - 2.325) - (1.545 - 2.265)]$$

$$= 0.04 \text{ m}$$

17. Ans: (c)

$$\begin{aligned}\text{Sol: } \alpha' &= \frac{S}{nD} (206265) \\ &= \frac{1.60 - 1.55}{4 \times 100} (206265) \\ &= 25.78 \text{ sec}\end{aligned}$$

18. Ans: (a)

$$\text{Sol: } 74.500 + 4.685 = 79.185 \text{ m}$$

19. Ans: (b)

$$\text{Sol: Error} = 0.015$$

$$e = e_{\text{col}} + e_c + e_r$$

$$\Rightarrow 0.015 = e_{\text{col}} + 0.06735 (1.5)^2$$

$$\Rightarrow e_{\text{col}} = -0.1365 \text{ m}$$

20. Ans: (d)

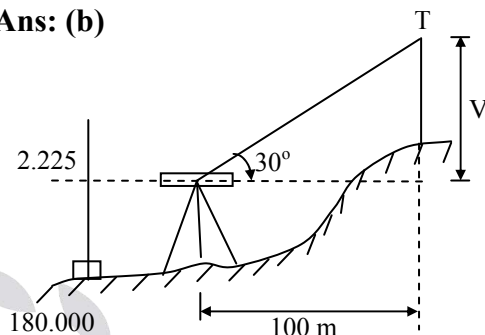
$$\text{Sol: } n = 1, R = 1.1 \text{ m}$$

$$\begin{aligned}\alpha' &= \frac{\ell}{R} = \frac{1}{1.1 \times 10^3} \\ &= \frac{1}{1100}\end{aligned}$$

07. Trigonometrical Levelling

01. Ans: (b)

Sol:

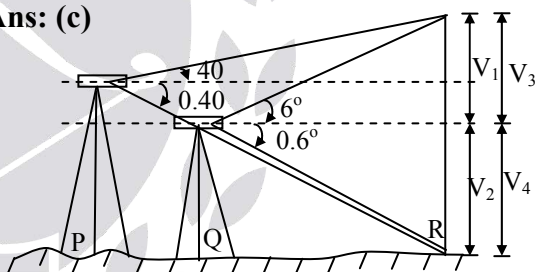


$$\begin{aligned}V &= 1000 \tan 30^\circ \\ &= 577.35 \text{ m}\end{aligned}$$

$$\begin{aligned}\text{R.L of T} &= 180 + 2.225 + 577.35 \\ &= 759.575 \text{ m}\end{aligned}$$

02. Ans: (c)

Sol:



$$V_1 + V_2 = V_3 + V_4$$

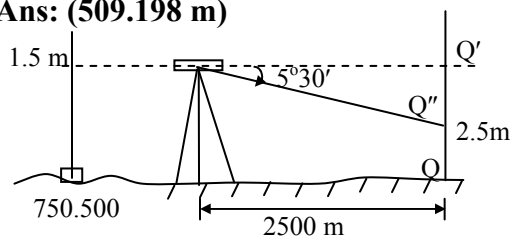
$$D(\tan 6^\circ + \tan 0.6^\circ) = (D + 250)(\tan 4^\circ + \tan 0.4^\circ)$$

$$\therefore D = 496.77 \text{ m}$$

$$\text{Height of tower, } V_1 + V_2 = 57.4266$$

03. Ans: (509.198 m)

Sol:



$$\text{Corr. S.R} = 2.5 - 0.06735 \times 2.5$$

$$= 20.79 \text{ m}$$

$$Q'Q'' = 2500 \tan 5^\circ 30'$$

$$= 240.723 \text{ m}$$

$$\text{R.L of Q} = 750.500 + 1.5 - 240.723 - 2.072$$

$$= 509.198 \text{ m}$$

04. Ans: (a)

$$\text{Sol: } 2.650 - 0.750 = V_2 - V_1$$

$$= (D + 100) \tan 14^\circ 30' - D \tan 20^\circ 30'$$

$$\therefore D = 207.806 \text{ m}$$

$$V_1 = 207.806 \tan 20^\circ 30' = 77.69 \text{ m}$$

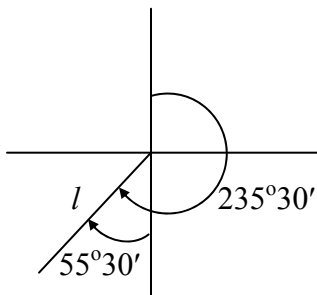
$$\text{R.L. of C} = 500 + 2.65 + 77.695$$

$$= 580.345 \text{ m}$$

08. Traversing & Omitted Measurements

01. Ans: (d)

$$\text{Sol: Given } L = -102.65 \text{ m}$$



$$L = \ell \cos \theta$$

$$-102.65 = \ell \times \cos (55^\circ 30')$$

$$\ell = -205.82 \text{ m}$$

$$\text{Departure (D)} = \ell \sin \theta$$

$$= -205.82 \sin (55^\circ 30')$$

$$= (-) 178.40 \text{ m}$$

02. Ans: -124.22, 174.99

$$\text{Sol: T.L of B} = -34.5 - 128 \cos 45^\circ 30'$$

$$= -124.22 \text{ m}$$

$$\text{T.D of B} = 83.7 + 128 \sin 45^\circ 30'$$

$$= 174.99 \text{ m}$$

$$B = (-124.22, 174.99)$$

03. Ans: (b)

$$\text{Sol: } L = \text{Latitude} = 89 \text{ m (N)}$$

$$D = \text{Departure} = -49.4 \text{ [W]}$$

$$\text{FB at PQ} \Rightarrow \theta = \tan^{-1} \left[\frac{D}{L} \right]$$

$$\theta = \tan^{-1} \left[\frac{49.4}{89} \right]$$

$$\theta = 29.03^\circ$$

$$\text{FB at PQ} = \text{N } 29.03^\circ \text{ W}$$

$$\text{WCB at PQ} = 360^\circ - 29.03^\circ$$

$$= 330.97^\circ$$

$$= 330^\circ 58'$$

04. Ans: (d)

$$\text{Sol: } P = 1500 \text{ m}$$

$$\text{Relative error} = \frac{1}{P/e} = \frac{1}{2343}$$

$$e = \sqrt{0.5^2 + 0.4^2} = 0.6403 \text{ m}$$

$$r = \frac{e}{p} = \frac{0.6403}{1500} = \frac{1}{2343} \text{ m}$$

05. Ans: (a)

Sol: $200\cos\theta + 98\cos 178^\circ + l \cos (270^\circ) + 86.4$

$$\cos (1^\circ) = 0$$

$$200 \sin\theta + 98\sin (178^\circ) + l \sin 270^\circ + 86.4$$

$$\sin 1^\circ = 0$$

$$l \cos (270^\circ) + 200 \cos \theta = 11.55$$

$$l \sin (270^\circ) + 200 \sin \theta = -4.92$$

$$200 \cos\theta = 11.55$$

$$\Rightarrow \theta = \cos^{-1}\left(\frac{1.55}{200}\right) = 86.7^\circ$$

$$\Rightarrow l = 204.588 \text{ m}$$

06. Ans: (c)

Sol:

	A	B
L	40	20
D	-20	30

$$\text{F.B} = \tan^{-1} \frac{30+20}{20-40} = 68^\circ 11'$$

$$= \text{S} 68^\circ 11' \text{ E}$$

$$\text{B.B} = \tan^{-1} \frac{-20-30}{40-20}$$

$$L_2 - L_1 = 20 - 40 = -20 \text{ (S)}$$

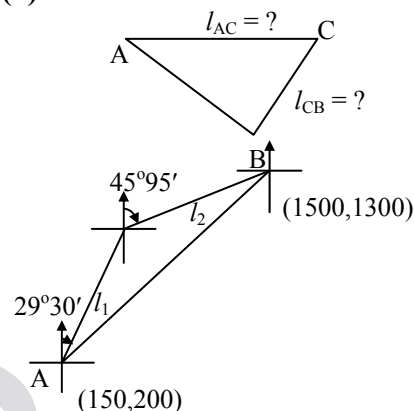
$$D_2 - D_1 = 30 - (-20) = 50 \text{ (E)}$$

$$\text{AB} = \sqrt{(-20)^2 + (50)^2}$$

$$= 53.85 \text{ m}$$

07. Ans: (a)

Sol:



FB of AC = N $29^\circ 30'$ E

FB of BC = S $45^\circ 45'$ W

$$\Sigma L = 1500 - 150 = l_1 \cos 29^\circ 30' + l_2 \cos 45^\circ 45'$$

$$\Sigma D = 1300 - 200 = l_1 \sin 29^\circ 30' + l_2 \sin 45^\circ 45'$$

$$1350 = l_1 \cos 29^\circ 30' + l_2 \cos 45^\circ 45' \dots\dots\dots (1)$$

$$1100 = l_1 \sin 29^\circ 30' + l_2 \sin 45^\circ 45' \dots\dots\dots (2)$$

By solving 1 & 2 $l_1 = 712.714 \text{ m}$

$$l_2 = 1045.7 \text{ m}$$

08. Ans: (b)

Sol: Length = $\sqrt{(1.39)^2 + (2.17)^2}$

$$= 2.577 \text{ m}$$

Closing error

$$\theta = \tan^{-1} \left(\frac{2.17}{1.39} \right) = 57^\circ 21'$$

$$360^\circ - \tan^{-1} \left(\frac{2.17}{1.39} \right) = 302^\circ 39'$$

09. Ans: (c)

Sol: $D = 10$

$$\theta = \tan^{-1}\left(\frac{10}{10}\right) = 45^\circ$$

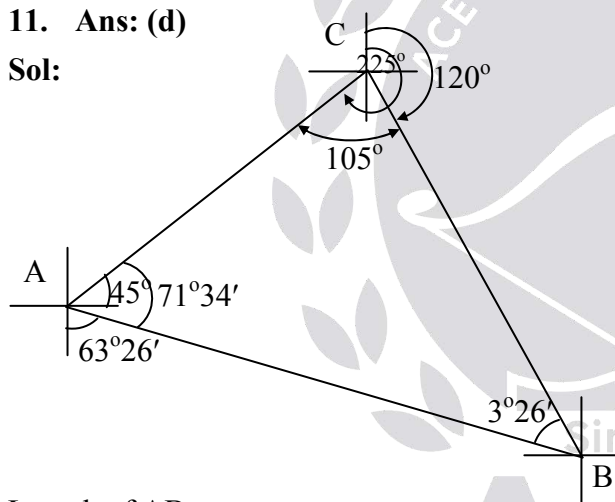
10. Ans: (a)

Sol: $\theta = \tan^{-1}\left(\frac{L}{D}\right)$

$$= \tan^{-1}\left(\frac{100}{60}\right) = 59^\circ 2'$$

11. Ans: (d)

Sol:



Length of AB =

$$\sqrt{(800 - 600)^2 - (600 - 500)^2} = 223.606 \text{ m}$$

$$\tan \alpha = \frac{200}{100} = 2$$

$$\alpha = 63^\circ 26'$$

The W.C.B of the line AB is $180^\circ - 63^\circ 26'$

$$= 116^\circ 34'$$

The Δ^{le} ACB,

$$\angle CAB = 116^\circ 34' - 45^\circ = 71^\circ 34'$$

$$\angle ACB = 225^\circ - 120^\circ - 105^\circ$$

$$\angle ABC = 180 - (71^\circ 34' + 105^\circ) = 3^\circ 26'$$

$$\frac{223.606}{\sin 105^\circ} = \frac{BC}{\sin(71^\circ 34')} = \frac{CA}{\sin(3^\circ 26')}$$

$$BC = 219.616 \text{ m}$$

$$CA = 13.863 \text{ m}$$

$$\text{Latitude of CA} = 13.863 \cos 225^\circ = -9.675$$

$$\text{Departure CA} = 13.863 \sin 225^\circ = -9.675$$

Independent coordinates of 'C'

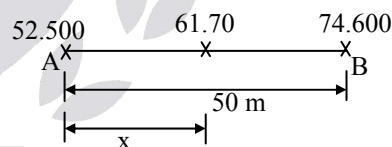
$$\text{East} = 600 + 9.675 = 609.675 \text{ m}$$

$$\text{North} = 600 + 9.675 = 609.675 \text{ m}$$

09. Contouring

01. Ans: (b)

Sol:



$$x = \frac{61.70 - 52.500}{74.600 - 52.50} \times 50$$

$$x = 20.82 \text{ m}$$

02. Ans: (d)

$$\text{Sol: } H.E = \frac{20}{(1/50)} = 1000 \text{ m}$$

$$R = \frac{1000}{25,000} = 0.04 \text{ m}$$

03. Ans: (c)

Sol: Scale : 1 : 20000

$$\text{Gradient} = \frac{4}{100}$$

$$\text{Interval} = 20 \text{ m}$$

$$\text{Radius} = \frac{20}{20000} = 2.5 \text{ cm}$$

10. Areas & Volumes

01. Ans: (d)

Sol: A (10, 20)

B (-30, 40)

C (50, -60)

D (70, -80)

$$m_1 = \frac{20}{2} = 10$$

$$m_2 = 10 + \frac{10}{2} + \frac{20}{2} = 40$$

$$m_3 = 40 + \frac{20}{2} - \frac{30}{2} = 30$$

$$m_4 = 30 - 30 - 40 = -40$$

$$\begin{aligned} A &= 10 \times 10 - 30 \times 40 + 30 \times 50 - 40 \times 70 \\ &= 100 - 1200 + 1500 - 2800 \\ &= -4000 + 1600 \\ &= -2400 \text{ m}^2 \end{aligned}$$

02. Ans: 2111 m³

Sol: b = 8.8 n = 1.5 d = 20

$$A = [b + nh] h$$

$$A_1 = [8.8 + 1.5 \times 1.8] 1.8 = 20.7 \text{ m}^2$$

$$A_2 = [8.8 + 1.5 \times 2.4] 2.4 = 29.76 \text{ m}^2$$

$$A_3 = [8.8 + 1.5 \times 3] 3 = 39.9 \text{ m}^2$$

$$A_4 = [8.8 + 1.5 \times 3.6] 3.6 = 51.12 \text{ m}^2$$

$$V = 20 \left[\frac{20.7 + 51.12}{2} + (29.76 + 39.9) \right]$$

$$V = 2111 \text{ m}^3$$

03. Ans: (d)

Sol:

Area of ABCDA

$$\begin{aligned} &= \frac{1}{2} \left| (-400 - 1500) + (1800 - 800) + (400 - 3000) \right. \\ &\quad \left. + (2500 + 200) \right| \\ &= 400 \text{ m}^2 \\ &= 0.04 \text{ hectare}^2 \end{aligned}$$

04. Ans: 288000 m³

Sol: Horizontal equivalent = $\frac{\text{Contour interval}}{\text{gradient}}$

$$= \frac{330 - 210}{\frac{1}{30}} = 3600 \text{ m}$$

$$1V - 0.5 H$$

$$4V - ? H = 8 \text{ m}$$

$$\begin{aligned} \text{Volume} &= \left(\frac{28 + 12}{2} \right) \times 3600 \times 4 \\ &= 288000 \text{ m}^3 \end{aligned}$$

05. Ans: (b)

Sol: $A_1 = 10 \times 4 = 40 \text{ m}^2$

$A_2 = 6 \times 2 = 12 \text{ m}^2$

$A_m = \left(\frac{10+6}{2} \right) \left(\frac{4+2}{2} \right)$

$= 8.2 = 24 \text{ m}^2$

$V = \frac{h}{6} [A_1 + 4A_m + A_2]$

$= \frac{8}{6} [40 + 4(24) + 12]$

$V = 197.33 \text{ m}^3$

06. Ans: (b)

Sol: $A = d \left[\frac{O_1 + O_n}{2} + O_2 + O_3 + \dots + O_{n-1} \right]$

$A_1 = 5 \left[\frac{5+6}{2} + 4 + 5.5 + 5 \right]$

$= 95$

$A_2 = 10 \left[\frac{6+4.5}{2} + 4 \right] = 92.5$

$A = A_1 + A_2 = 187.5 \text{ m}^2$

07. Ans: (b)

Sol: $A = M [F.R - I.R \pm 10 N + C]$

$A = 10,000 [2.64 - 6.356 + 10 \times 3 + 0]$

$A = 2,62,840 \text{ mm}^2$

08. Ans: (38, 160 m²)

Sol: $A = M [FR - IR \pm 10 N + C]$

$= 10 [7284 - 3468 - 10 \times 2 + 20]$

$= 38,160 \text{ mm}^2 \text{ (on the plan)}$

Scale 1:1000

$1 \text{ mm} = 1 \text{ m}$

$= (38,160 \times 1 \times 1) \text{ m}^2$

$= 38,160 \text{ m}^2$

09. Ans: (b)

Sol: $V = \frac{h}{3} [\text{first} + \text{last} + 4(\text{even}) + 2(\text{odd})]$

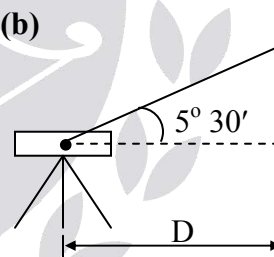
$= \frac{5}{3} [(3850 + 450) + 4(3450 + 800) + 2(2600)]$

$= 44166.66 \text{ m}^3$

11. Tacheometry

01. Ans: (b)

Sol:



⇒ With an allactic lens

$k = 100 \quad C = 0$

$D_1 = ks \cos^2 \theta + C \cos \theta$

$D_1 = 100 \times 1.750 \times \cos^2 5^\circ 30'$

$D_1 = 173.39 \text{ m}$

⇒ With $K = 101$ & $C = 0.6$

$D_2 = KS \cos^2 \theta + C \cos \theta$

$D_2 = 101 (1.75) \cos^2 (5^\circ 30') + 0.6 \cos (5^\circ 30')$

$D_2 = 175.72 \text{ m}$

$$\% \text{ age of error} = \frac{D_1 - D_2}{D_1} \times 100$$

$$= \frac{175.72 - 173.39}{173.39} \times 100$$

$$\% \text{ age of error} = 1.35\%$$

02. Ans: (a)

Sol: $L = KS + C$

$$50 = 0.495 K + C$$

$$80 = 0.795 K + C$$

$$K = 100, C = 0.5$$

03. Ans: (d)

Sol: $f = 25 \text{ cm} = 250 \text{ mm}, i = 5 \text{ mm}$

$$\text{m.c} \Rightarrow K = \frac{f}{i} = \frac{250}{5} = 50$$

$$\text{A.C} \Rightarrow C = f + d = 250 + 15 \text{ cm} = 40 \text{ cm}$$

$$= 40 \times 10^{-2} \text{ m}$$

$$C = 0.40 \text{ m}$$

04. Ans: (a)

Sol: Horizontal distance, $D = Ks \cos^2 \theta + C \cos \theta$

$$K = 100; C = 0$$

$$= 100 \times (2.985 - 2.225) \cos^2 (7^\circ 54')$$

$$= 74.564 \text{ m}$$

05. Ans: (d)

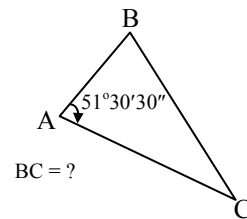
Sol: $D = KS + C$

$$K = 95, S = 2.65 - 0.65$$

$$D = 95(2.65 - 0.65) + 0.5 = 190.5 \text{ m}$$

06. Ans: (27.746 m)

Sol:



$$AB = 100 \times 0.35 + 0.2 = 35.2 \text{ m}$$

$$AC = 100 \times 0.25 + 0.2 = 25.2 \text{ m}$$

$$\cos 51^\circ 30' 30'' = \frac{AB^2 + AC^2 - BC^2}{2AB \times AC}$$

$$BC = 27.746 \text{ m}$$

07. Ans: (b)

$$\text{Sol: } D = \frac{S}{\tan \alpha_1 + \tan \alpha_2} = \frac{2}{\tan(1^\circ 12') + \tan(1^\circ 30')} = 42.43 \text{ m}$$

$$V = D \tan \alpha_2 = 42.43 \tan(1^\circ 30') = 1.112$$

$$\text{R.L of A} = 100 - 1.12 - 0.5 = 98.39 \text{ m}$$

08. Ans: (a)

$$\text{Sol: } D = (206265) \frac{S}{\beta}$$

$$\beta = (30 \times 60) + 15 = 1815$$

$$D = (206265) \frac{1.25}{1815} = 142.06 \text{ m}$$

09. Ans: (d)

$$\text{Sol: } D = \frac{KS}{m} \cos^2 \theta + C \cos \theta$$

$$= \frac{1000 \times 2}{m} \cos^2 6^\circ + 0.5 \cos 6^\circ$$

$$\therefore m = 19.88$$

12. Horizontal & Vertical Curves

01. Ans: (c)

Sol: $D = 2^\circ$

Chord length = 30 m

$$\Delta = 30^\circ$$

$$\ell = \frac{30\Delta}{2}$$

$$\ell = \frac{30 \times 30}{2}$$

$$\ell = 450 \text{ m}$$

$$\ell = \frac{\pi R \Delta}{180}$$

$$\frac{450 \times 180}{\pi \times 30} = R$$

$$R = 859.44 \text{ m}$$

$$\text{Apex distance} = R [\sec \Delta/2 - 1]$$

$$= 859.44 \left[\sec \frac{30}{2} - 1 \right]$$

$$= 30.32 \text{ m}$$

02. Ans: (a)

Sol: $l = 2 R \sin \Delta/2$

$$341.6 = 2 \times R \sin \left(\frac{42}{2} \right)$$

$$R = 476.61 \text{ m}$$

$$\ell = \frac{\pi \times R \Delta}{180}$$

$$\ell = \frac{\pi \times 476.61 \times 42}{180}$$

$$\ell = 349.4 \text{ m}$$

03. Ans: (c)

$$\begin{aligned} \text{Sol: Offset} &= R - \sqrt{R^2 - x^2} \\ &= 500 - \sqrt{500^2 - 20^2} \\ &= 0.4 \text{ m} \end{aligned}$$

04. Ans: (c)

$$\begin{aligned} \text{Sol: } O_o &= R - \sqrt{R^2 - \left(\frac{L}{2} \right)^2} \\ &= 80 - \sqrt{80^2 - \left(\frac{100}{2} \right)^2} = 17.5 \text{ m} \end{aligned}$$

05. Ans: (b)

$$\begin{aligned} \text{Sol: } L &= 2R \sin \frac{\Delta}{2} \\ &= 2 \times 600 \times \sin 30^\circ \\ &= 600 \text{ m} \\ \text{Mid ordinate} &= R \left(1 - \cos \frac{\Delta}{2} \right) \\ &= 600 (1 - \cos 30^\circ) \\ &= 80.38 \text{ m} \end{aligned}$$

06. Ans: (c)

$$\begin{aligned} \text{Sol: Tangent length} &= R \tan \frac{\Delta}{2} \\ &= 200 \times \tan 30^\circ \\ &= 115.47 \text{ m} \end{aligned}$$

07. Ans: (92.82 m)

$$\text{Sol: Apex distance} = R \left(\sec \frac{\Delta}{2} - 1 \right) = 92.82 \text{ m}$$

08. Ans: (a)

Sol: Tangent length = $600 \tan 15^\circ$

$$= 160.77 \text{ m}$$

$$\text{Length of curve} = \frac{\pi R \Delta}{180} = 314.15 \text{ m}$$

$$\text{Change of point of curve} = 1650 - 160.77 \\ = 1489.23 \text{ m}$$

$$\text{Point of tangency} = 1489.23 + 314.15 \\ = 1803.39 \text{ m}$$

09. Ans: (d)

$$\text{Sol: } \ell = \frac{30\Delta}{D} = \frac{30 \times 60}{3} = 600 \text{ m}$$

10. Ans: (b)

$$\text{Sol: } L = \frac{g_1 - g_2}{r} = \frac{-1.5 - (-3.7)}{\left(\frac{0.1}{30}\right)} \\ = 660 \text{ m}$$

11. Ans: (a)

Sol:

$$L = \frac{0.80 - (-0.70)}{\left(\frac{0.05}{1}\right)} \\ = 30 \text{ chains}$$

12. Ans: (c)

Sol: $L = nh$

$$= 200 \times 100$$

$$= 20000 \text{ mm}$$

$$= 20 \text{ m}$$

13. Ans: (c)

Sol: $n = 40 \text{ mm}$

$$h = 100 \text{ mm}$$

$$V = 20 \text{ m/sec}$$

$$L = \frac{hV}{x} = \frac{100 \times 20 \times 1000}{40}$$

$$= 50000 \text{ mm}$$

$$= 50 \text{ m}$$

14. Ans: (88.88 m)

Sol: $V = 20 \text{ m/sec}$

$$a = 0.3$$

$$r = 300 \text{ m}$$

$$L = \frac{v^3}{R\alpha} = \frac{20^3}{300 \times 0.3} \\ = 88.88 \text{ m}$$

15. Ans: (a)

$$\text{Sol: } \frac{V^2}{Rg} = \frac{1}{8}$$

$$\Rightarrow R = 2 \times 78.67 \\ = 157.34 \text{ m}$$

16. Ans: (61.75 kmph)

$$\text{Sol: } h = \frac{GV^2}{Rg}$$

$$\Rightarrow V = \sqrt{\frac{hRg}{G}} = \sqrt{\frac{0.100 \times 300 \times 9.81}{G}} \\ = 17.155 \text{ m/s}$$

$$\text{Velocity} = 17.155 \times \frac{18}{5} \\ = 61.75 \text{ kmph}$$

13. Errors & Adjustments

01. Ans: (48° 16' 22.87")

Sol: $\angle A + \angle B + \angle C = 179^\circ 59' 50.6''$

$$d = +9.4''$$

$$C_c = \left[\frac{e_c^2}{e_A^2 + e_B^2 + e_c^2} \right] d$$

$$= \left[\frac{2^2}{4^2 + 6^2 + 2^2} \right] 9.4''$$

$$C_c = 0.67''$$

$$\text{Corrected angle} = [48^\circ, 16' 22.2''] + 0.67''$$

$$= 48^\circ 16' 22.87''$$

02. Ans: (a)

Sol: $A \rightarrow 5$

$$\frac{\text{wt of } 3A}{\text{wt of } A/4} = \frac{5/9}{80}$$

$$= \frac{5}{720}$$

03. Ans: $22500 \pm 3 \text{ m}^2$

Sol: Given, side of square (a) = 150 m

$$\text{Error } (e_a) = \pm 0.010 \text{ m}$$

$$\text{Area} = a^2 = (150)^2 = 22500 \text{ m}^2$$

$$e_A = 2a \cdot e_a$$

$$= 2 \times 150 \times 0.010$$

$$= \pm 3 \text{ m}^2$$

$$\text{Probable value} = 22500 \pm 3 \text{ m}^2$$

04. Ans: (d)

Sol: Most probable value

$$= \frac{42^\circ 12' 35'' + 84^\circ 25' 15'' + 168^\circ 50' 23''}{7}$$

$$= 42^\circ 12' 36''$$

05. Ans: (d)

Sol: As per laws of weights, "If a quantity of given weight is divided by a factor, the weight of the result is obtained multiplying its given weight by the square of the factor".

$$3^2 \times 5 = 45$$

06. Ans: (b)

Sol: MPV or WAM

$$= 40^\circ + \frac{20 \times 2 + 30 \times 3 + 45 \times 9}{2 + 3 + 4}$$

$$= 40^\circ 34' 26.67''$$

07. Ans: (a)

$$\text{Sol: } \angle A = 47^\circ 32' 30'' \pm 2'' - e_A$$

$$\angle B = 24^\circ 16' 40'' \pm 3'' - e_B$$

$$E_C = \pm \sqrt{e_A^2 + e_B^2}$$

$$= \pm \sqrt{2^2 + 3^2} = \pm 3.605''$$

08. Ans: (d)

$$\text{Sol: } e_B = \pm \sqrt{e_a^2 + e_b^2 + e_c^2}$$

$$= \pm \sqrt{1^2 + 1^2 + 1^2} = \pm \sqrt{3}''$$

09. Ans: (c)

Sol: Radius, $r = 12.25$

$$e_r = \pm 0.03 \text{ m}$$

$$A = \pi r^2$$

$$e_A = 2\pi r e_r \\ = \pm 2.309 \text{ m}^2$$

10. Ans: $471.4352 \pm 2.309 \text{ m}^2$

Sol: MPV of an area

$$= A \pm e_A \\ = (\pi \times 12.25^2) \pm 2.309 \\ = 471.4352 \pm 2.309 \text{ m}^2$$

11. Ans: ($\pm 1.32 \text{ m}$)

Sol: $C = 2\pi r \quad e_c = 2\pi e_r$

$$= \pm 2 \times \pi \times 0.21 \\ = \pm 1.32 \text{ m}$$

12. Ans: (d)

Sol: $\angle A = 20^\circ 10' \pm 0.2$

$$\angle B = 100^\circ 40' \pm 0.1$$

$$\angle C = 59^\circ 10' \pm 0.2$$

$$e_s = \pm \sqrt{0.2^2 + 0.1^2 + 0.2^2} \\ = \pm 0.3$$

13. Ans: 3.162 m^2

Sol: $e_a = \pm 0.02 \text{ m} \quad e_b = \pm 0.01 \text{ m}$

$$A = ab$$

$$e_A^2 = \left(\frac{\partial A}{\partial a} \right)^2 e_a^2 + \left(\frac{\partial A}{\partial b} \right)^2 e_b^2$$

$$\frac{\partial A}{\partial a} = b = 150$$

$$\frac{\partial A}{\partial b} = a = 100$$

$$e_A^2 = 150^2 (0.02)^2 + 100^2 (0.01)^2$$

$$\Rightarrow e_A = \pm 3.162 \text{ m}^2$$

$$\text{MPV} = 15000 \pm 3.162 \text{ m}^2$$

14. Ans: (d)

Sol: $E \propto \sqrt{\ell}$

$$\frac{E_1}{E_2} = \sqrt{\frac{\ell_1}{\ell_2}} \quad (\text{or}) \quad \frac{0.09}{E_2}$$

$$(\text{or}) E_2 = \pm 0.08 \text{ m}$$

15. Ans: (c)

Sol: $V = ab c$

$$e_A^2 = (4 \times 3)^2 0.02^2 + (3 \times 3)^2 (0.01)^2 + (3 \times 4)^2 (0.02)^2 = \pm 0.35 \text{ m}$$

16. Ans: (d)

Sol: $\frac{1}{\frac{1}{3} + \frac{1}{2}} = \frac{6}{5}$

15. Photogrammetry
01. Ans: (d)
Sol: $r = 86 \text{ mm}$

$$d = \frac{rh}{H} = \frac{86 \times 10^{-3} \times 600}{4500}$$

$$= 0.011466 \text{ m}$$

$$= 11.466 \text{ mm}$$

02. Ans: (c)

Sol: $S = \frac{f}{H-h}$

$$= \frac{152 \times 10^{-3}}{1800 - 300}$$

$$= \frac{1}{9868}$$

03. Ans: (a)

Sol: $\frac{\text{Photoscale}}{\text{Mapscale}} = \frac{\text{P.D.}}{\text{M.D.}}$

$$\Rightarrow \text{PS} = \frac{188 \times 10^{-3}}{120 \times 10^{-3}} \times \frac{1}{20,000}$$

$$= \frac{1}{12766}$$

04. Ans: 406

Sol: $N_1 = \left[\frac{L_1}{L} + 1 \right]$

$$N_2 = \left[\frac{W_1}{W} + 1 \right]$$

$$L = (1 - 0.6) \times \frac{230 \times 10^{-3}}{\frac{1}{10,000}} = 0.92 \text{ km}$$

$$W = (1 - 0.3) \frac{230 \times 10^{-3}}{\frac{1}{10,000}} = 1.61 \text{ km}$$

$$N_1 = \frac{L_1}{L} + 1 = \frac{25}{0.92} + 1 = 28.17$$

$$N_2 = \frac{W_1}{W} + 1 = \frac{20}{1.61} + 1 = 13.42$$

$$N = N_1 \times N_2 = 406$$

05. Ans: (c)
Sol: $H = 1500 \text{ m}$

$$h_1 = 250 \text{ m}$$

$$d = 115.4 \times 10^{-3}$$

$$r = 190 \times 10^{-3} \text{ m}$$

$$d = \frac{r_2 h_2}{H - h_1} = 996.05 \text{ m}$$

06. Ans: (a)
Sol: focal length = 21.5 cm

$$= 21.5 \times 10^{-2} \text{ m}$$

$$S = \frac{1}{45,000}$$

$$\text{P.D} = 11 \times 10^{-2} \text{ m}$$

$$\text{M.D} = 3 \times 10^{-2} \text{ m}$$

$$h = 350 \text{ m}$$

$$H = ?$$

$$S = \frac{f}{H-h}$$

$$\frac{\text{Photoscale}}{\text{Mapscale}} = \frac{11 \times 10^{-2}}{3 \times 10^{-2}}$$

$$\Rightarrow \frac{21.5 \times 10^{-2}}{\frac{4-350}{1}} = \frac{11 \times 10^{-2}}{3 \times 10^{-2}} \Rightarrow H = 2988.637 \text{ m}$$

07. Ans: (a)

$$\text{Sol: } V = \frac{L}{t} \times 3600 = 216 \text{ kmph}$$

08. Ans: 620

Sol: $R = ?$

$$h_a = 650 \text{ m}, h_b = 250 \text{ m}$$

$$f = 250 \times 10^{-3}$$

$$H = 2700$$

$$X_A = 299.3 \text{ m}$$

$$Y_B = 547.82$$

$$Y_A = +208.28 \text{ m}$$

$$X_B = -220.5 \text{ m}$$

$$\sqrt{(X_A - X_B)^2 + (Y_A - Y_B)^2} = 620 \text{ m}$$

09. Ans: (a)

$$\text{Sol: } S_d = \frac{f}{H} \Rightarrow \frac{1}{8000} = \frac{25 \times 10^{-3}}{H}$$

$$\therefore H = 2000 \text{ m}$$

$$d = \frac{r_1 h_1}{(H - h_1)}$$

$$= \frac{7.50 \times 10^{-2} \times 350}{2000 - 350}$$

$$= 0.015 \text{ m} = 15.9 \text{ mm}$$

10. Ans: (d)

$$\text{Sol: } d = r_2 - r_0$$

$$= 112.5 - 82.40 = 30.1 \text{ mm}$$

$$h_2 = \frac{d(H - h_1)}{r_2}$$

$$= \frac{30.1}{112.5} \times (700 - 250)$$

$$= 120.4 \text{ m}$$

11. Ans: 88.68

$$\text{Sol: } \Delta h = \frac{\Delta PH'}{b}$$

$$= \frac{3.5 \times (3000 - 200)}{110.5}$$

$$= 88.68 \text{ m}$$

16. Triangulation

01. Ans: (c)

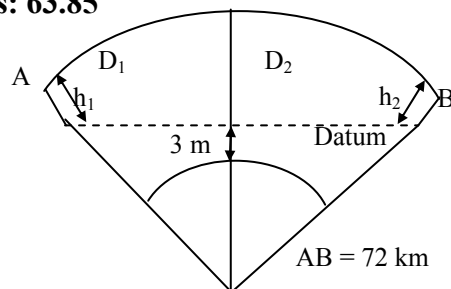
$$\text{Sol: } \alpha = \frac{r \cos^2 \theta / 2}{D}$$

$$= 206265 \times \frac{7.5 \times 10^{-2} \times \cos^2 60 / 2}{10 \times 10^3}$$

$$= 1.16''$$

02. Ans: 63.85

Sol:



Minimum elevation of line of light

$$= 328 + 3 = 331 \text{ m}$$

(Take as a reference)

$$\text{Height of A} = 372 - 331 = 41 \text{ m}$$

If line of sight from A strike the ground at

D_1

$$D_1 = \sqrt{\frac{h_1}{0.06735}} = 24.673 \text{ km}$$

$$\therefore D_2 = 47.327 \text{ km}$$

$$h_2 = 0.06735 D_2^2 = 150.85 \text{ m}$$

Elevation of signal at B

$$331 + 150.85 = 481.85 \text{ m}$$

$\therefore$ Signal @ B to be required to elevate

$$= 481.85 \text{ m} - 418 = 63.85$$

03. Ans: (b)

$$\text{Sol: } D = 8560 \text{ m}$$

$$r = \frac{140}{2} = 70 \text{ mm}$$

$$\theta = 50^\circ$$

$$\alpha = \frac{206265 \times 70 \times 10^{-3} \times \cos^2\left(\frac{50}{2}\right)}{8560} = 1.53''$$